250 mg of Adams' catalyst. Employing the usual work-up procedure, 760 mg (95%) of crude product (**16a**) was isolated. Recrystallization from ethyl acetate–ether afforded an analytical sample as colorless needles: mp 125–127°; $\nu_{max}^{CHCl_3}$ 1680 cm^{-1} (strong), no N^+–H or N^+H_2 bands; λ_{max}^{EtOH} 228 mμ (ϵ ~7000).

Anal. Calcd for $C_{16}H_{29}ClN_2O_5$: C, 52.67; H, 8.01; N, 7.68. Found: C, 52.66; H, 7.99; N, 7.94.

Upon heating **16a** in 10% aqueous sodium hydroxide at 70° for 2 hr, the salt was gradually converted to an immiscible oil. This was extracted into ether, the combined extracts were dried, and the ether was removed *in vacuo*. The residual oil (**17a**) had ν_{max}^{film} 3300, 1710 cm^{-1} (strong); nmr (in $CDCl_3$) at τ 7.22 (s, 2 H), 7.35 (q, 2 H), 7.5–8.7 (complex multiplet, 13 H), 8.74 (s, 3 H), 8.89 (t, 3 H), and 8.97 (singlet over doublet, 6 H).

In a similar fashion, 443 mg (1.0 mmole) of adduct **15b** underwent hydrogenolysis to yield 274 mg (78%) of crude product (**16b**). The analytical sample, colorless needles from ethyl acetate–ether, had mp 167–170°; $\nu_{max}^{CHCl_3}$ 1680 cm^{-1} (strong), no N^+–H or N^+H_2 bands; λ_{max}^{EtOH} 227 mμ (ϵ ~8000).

Anal. Calcd for $C_{15}H_{27}ClN_2O_5$: C, 51.34; H, 7.75; N, 7.98. Found: C, 51.25; H, 7.90; N, 7.60.

Lithium Aluminum Hydride Reduction of Adduct 15b.—To a slurry of 380 mg (10.0 mmoles) of lithium aluminum hydride in 25 ml of 1,2-dimethoxyethane was added 885 mg (2.0 mmoles) of adduct **15b**. After 28 hr of heating under reflux, the mixture was treated dropwise with 0.76 ml of water and 0.61 ml of 10% aqueous sodium hydroxide. The precipitated salts were filtered and washed with hot solvent. The filtrate was then acidified with aqueous hydrochloric acid and evaporated *in vacuo*. Treatment of the residue with 10% aqueous sodium hydroxide followed by extraction with ether and the usual isolation procedure afforded 623 mg (91%) of crude *N-[1-(2',2'-dimethylpyrrolidin-1'-oxy)cyclohexanemethyl]-N-ethylbenzylamine* (**18b**) as a yellow oil; nmr (in $CDCl_3$) at τ 2.68 (m, C_6H_5), 6.27 (s, $ArCH_2N$), 6.7–7.2 (unresolved multiplet, CH_2NO), 7.46 (q, CH_3CH_2N), 7.48 (s, $CH_2N(C_2H_5)CH_2C_6H_5$), 8.1–8.8 (m, CCH_2CH_2C and $(CH_2)_5$), 8.96 (s, $(CH_3)_2CN$), and 9.03 (t, CH_3CH_2N).

Zinc–Acetic Acid Reduction of 18b.—A mixture of 480 mg (1.4 mmoles) of **18b** and 1.0 g of activated zinc dust[26] in 20 ml of 50% aqueous acetic acid was heated at 60–65° with vigorous stirring for 22 hr. At the end of this period, the residual zinc was filtered and washed with ethanol. The filtrate was then acidified with aqueous hydrochloric acid and the solvents were evaporated *in vacuo*. Basification of the residue with 30% aqueous sodium hydroxide followed by extraction with ether and the usual work-up procedure yielded a yellow oil. Chromatography on silica gel using ether–pentane for elution afforded 106 mg (31%) of *1-(N-benzyl-N-ethylaminomethyl)-1-cyclohexanol* (**19**): nmr (in $CDCl_3$) at τ 2.70 (s, C_6H_5), 6.29 (s, $ArCH_2N$), 7.01 (s, OH), 7.45 (q, CH_3CH_2N), 7.52 (s, $CH_2N(C_2H_5)CH_2C_6H_5$), 8.52 (unresolved multiplet, $(CH_2)_5$), and 9.00 (t, CH_3CH_2N).

1-(N-Benzyl-N-ethylaminomethyl)-1-cyclohexanol (**19**).—A mixture of 3.3 g (10 mmoles) of 1-benzyl-1-ethyl-1-azoniaspiro[2.5]octane perchlorate (**14**) and 50 ml of water was allowed to stand at room temperature for 9 days. Subsequent treatment with 10% aqueous sodium hydroxide liberated a free amine which was extracted into ether. The combined extracts were dried, filtered, and evaporated *in vacuo* to yield the crude amino alcohol as a yellow oil. The nmr spectrum of this material proved to be identical with that of the product from the zinc–acetic acid reduction of **18b**.

Registry No.—**4a**, 14172-85-1; **4b**, 14172-86-2; **8a**, 14123-46-7; **8b**, 14123-47-8; **9**, 14123-48-9; **10**, 7005-47-2; **11a**, 14123-50-3; **11b**, 14123-51-4; **12**, 14123-52-5; **15a**, 14123-53-6; **15b**, 14123-54-7; **16a**, 14123-55-8; **16b**, 14123-56-9; **17a**, 14123-57-0; **18b**, 14123-58-1; **19**, 14123-59-2.

Nucleophilic Displacements of 3 Substituents in 1-Methyl-4-phenyl-1,2,3,6-tetrahydropyridines

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The substitution reactions at the 3 position of 3-substituted 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridines occur without participation of the heterocyclic nitrogen. Attempts to study the role of the allylic system in the displacement by deuterium labeling was hindered since the allylic cation formed readily, leading to a scrambling of the isotopic label.

The reactions of 3-halopiperidines and 3-piperidyl esters often occur with the participation of the nitrogen atom, forming an aziridinium ion, and with some ring contraction to the pyrrolidine.[2-6] A similar participation of the double bond of an allylic system would be anticipated. Thus the nucleophilic displacement reaction with 3-substituted 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridines could go by a variety of mechanisms, SN1, SN2, and SN2′ of the allylic system or by nitrogen participation. The product analysis of solvolysis reactions of 1-methyl-4-phenyl-3-halo-1,2,3,6-tetrahydropyridine (**1b** and **d**) should give indication of any nitrogen participation, and the location of a deuterium label after reactions of 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol-d_5 (**1c**-d_5) should indicate the role of the double bond.

Preparation of the 1-Methyl-3-halo-4-phenyl-1,2,3,6-tetrahydropyridines.—The reaction of 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (**1a**) hydrobromide with bromine was reported to give 1-methyl-3,4-dibromo-4-phenylpiperidine hydrobromide (**2**).[7] On heating **2** was converted into a new compound whose properties were consistent with the structure 1-methyl-3-bromo-4-phenyl-1,2,3,6-tetrahydropyridine hydrobromide (**1b**). The identical compound could be prepared by reaction of 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol (**1c**)[8] with phosphorus tribromide. The corresponding chloro derivative, **1d**, was obtained by treatment of **1c**, as the hydrochloride, with thionyl chloride. 1-Methyl-3-chloro-4-phenyl-1,2,3,6-tetrahy-

(1) This research was abstracted in part from the Thesis of W. E. Krueger presented to the Graduate Faculty of the University of New Hampshire in partial fulfillment of the requirements of the Ph.D. degree.

(2) R. H. Reitsema, *J. Am. Chem. Soc.*, **71**, 2041 (1949).

(3) J. Biel, L. G. Abood, W. K. Hoya, H. A. Liesner, P. A. Nufer, and E. F. Kluchdsky, *J. Org. Chem.*, **26**, 4096 (1961).

(4) E. Smissman, R. P. Quintana, and J. H. Biel, Abstracts, 139th National Meeting of the American Chemical Society, St. Louis, Mo., March 1961, p 35N.

(5) E. G. Brain, F. P. Doyle, and M. P. Mihta, *J. Chem. Soc.*, 633 (1961).

(6) C. F. Hammer and S. R. Heller, *Chem. Commun.*, 919 (1966).

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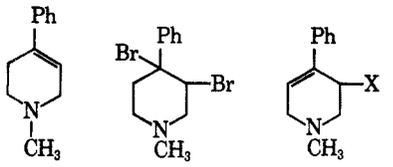
(8) R. E. Lyle and W. E. Krueger, *J. Org. Chem.*, **32**, 2873 (1967).

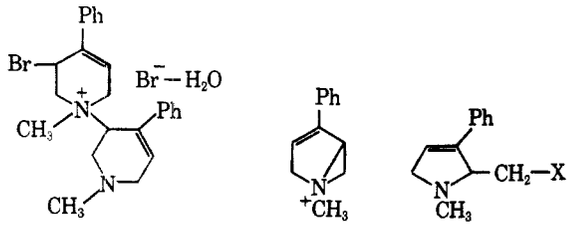
dropyridine salt (**1d**) was also obtained from the reaction of 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol (**1c**) hydrochloride with *p*-toluenesulfonyl chloride in dimethylformamide.



1a **2** **1b**, X = Br; **c**, X = OH; **d**, X = Cl; **e**, X = OAc

The Reaction of 1-Methyl-3-halo-4-phenyl-1,2,3,6-tetrahydropyridine Salts (1b, d) with Base.—The conversion of the hydrobromide of **1b** to the base with aqueous carbonate gave an ether-soluble oil which, on standing in ether, deposited an ether-insoluble solid which was shown to have the composition $C_{24}H_{30}Br_2N_2O$. The spectral properties of this compound were consistent with the structure 1-methyl-1-[3-(1-methyl-4-phenyl-1,2,3,6-tetrahydropyridyl)]-3-bromo-4-phenyl-1,2,3,6-tetrahydropyridinium bromide monohydrate (**3**). This reaction showed that the base of **1b** did not give an instantaneous solvolysis with an aqueous medium, and the displacement of the halide could be investigated using the amine form.

The reaction of the 3-chloro-**1d** or the 3-bromo-**1b** derivative with aqueous hydroxide gave high yields of 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol (**1c**) as the only product detectable by gas–liquid partition chromatography. These data seem to eliminate the possibility of the displacement occurring with nitrogen participation, for an aziridinium ion intermediate of the type **4** would be expected to lead to significant yields of the pyrrolidine **5**.[2-6]

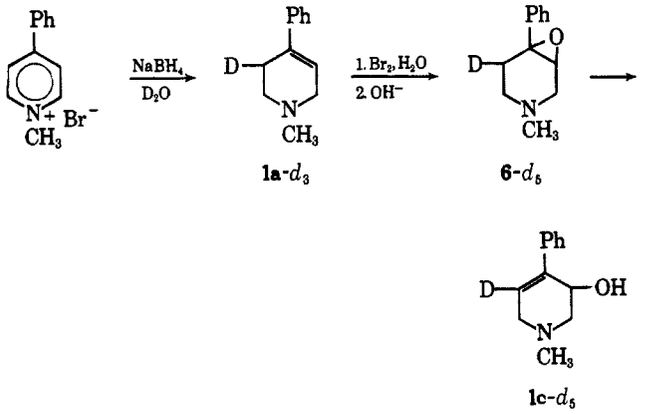


3 **4** **5**

The rearrangement of esters of 3-piperidinols have been reported to occur on heating or distillation of the esters.[4] Since nitrogen participation should have a better opportunity to occur under these conditions with the derivatives of **1c**, the thermal stability of 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridyl acetate (**1e**) was investigated. The acetate **1e** was distilled slowly under reduced pressure at a temperature of 177–179°. The distillate was shown to be homogeneous to gas chromatographic analysis and saponification of the ester gave only **1c**.

In view of the lack of participation of the nitrogen in substitution reactions of the **1** derivatives it seemed of interest to investigate the manner in which the allylic halides were undergoing the displacement reactions. Thus 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine-d_3 (**1a**-d_3) was prepared.[9] Bromination of the hydrobromide of **1a**-d_3 and heating of the product gave 1-methyl-3-bromo-4-phenyl-1,2,3,6-tetrahydropyridine-*d* hydrobromide (**1b**-*d*). The nmr analysis of **1b**-*d* showed that the deuterium label was equally distributed between the 3 and 5 positions of the tetrahydropyridine ring. Thus this route could not be used as a method of synthesis of **1b**-d_5, and the scrambling of the label strongly suggested that **1b** readily dissociated into ions with concurrent allylic rearrangement.

The reaction of **1a**-d_3 with bromine–sodium bromide in water followed by treatment with base gave 1-methyl-4-phenyl-3,4-epoxypiperidine-d_5 (**6**-d_5).[10] The reaction of **6**-d_5 with phenyllithium gave 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol-d_5 (**1c**-d_5).[8] The nmr spectrum of **1c**-d_5 showed the area of signal for the vinyl proton to be 50% of that of the carbinol hydrogen. Thus the elimination proceeded with the conversion of **6**-d_5 to **1c**-d_5 with no detectible isotope effect.



1a-d_3 **6**-d_5 **1c**-d_5

All attempts to convert **1c**-d_5 to a 3-halo derivative occurred with scrambling of the deuterium between the 3 and 5 positions. The reaction of **1c**-d_5 hydrochloride with thionyl chloride or *p*-toluenesulfonyl chloride give 1-methyl-3-chloro-4-phenyl-1,2,3,6-tetrahydropyridine-*d* (**1d**-*d*) with the deuterium equally distributed between the 3 and 5 positions. Thus the acidic conditions required for the preparation of the 3-halo derivative **1b** or **1d** promote allylic carbonium ion formation and preclude the synthesis of **1b** or **1d** with specific labeling of the 5 position.

Conformational Preference of the Tetrahydropyridines.—The failure to observe nitrogen participation in the substitution reactions and the ease of carbonium ion formation may have a partial explanation in the preferred conformation of the derivatives of **1**. The preferred conformation of 6-substituted 1-phenylcyclohexenes has been shown often to have the 6 substituent in the pseudo-axial arrangement.[11] The dihedral angle between the bonds of the equatorial 1 and 6 substituents of the cyclohexenes is less than that with the corresponding cyclohexane, and the presence of the double bond removes one of the 1,3-diaxial interactions. These factors probably are responsible for this conformational preference.[12]

The factors which might lead to the pseudo-axial arrangement of the 6 substituent in the 1-phenylcyclo-

(9) R. E. Lyle, D. A. Nelson, and P. S. Anderson, *Tetrahedron Letters*, 553 (1962).

(10) R. E. Lyle and W. E. Krueger, *J. Org. Chem.*, **30**, 394 (1965).

(11) E. W. Garbisch, *ibid.*, **27**, 4243, 4249 (1962); *J. Am. Chem. Soc.*, **85**, 927 (1963).

(12) F. Johnson and S. K. Malhotra, *ibid.*, **87**, 5492 (1965).

hexenes are operative in the analogous 3-substituted 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridines (**1**) except that the 1,3-diaxial interaction is now between the substituent at the 3 position and a pair of electrons. The predominant evidence suggests that this interaction should be less than that between that of the 3 substituent and hydrogen.[13]

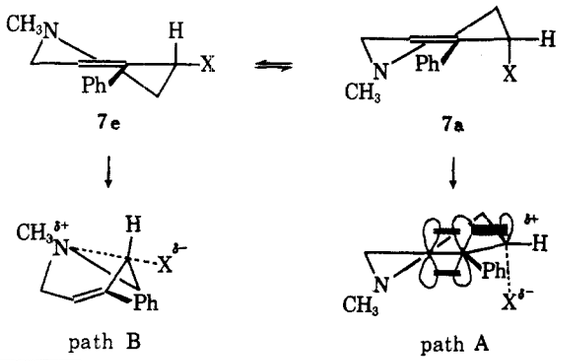
The conformational preference of the 3 substituent in the 3-substituted 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridines (**1**) was estimated from the band width at one-half height (W_h) of the nmr signal for the 3 proton. Whether the models were chosen from the cyclohexane series as used by Garbisch[11] (*cis*- and *trans*-4-*t*-butylcyclohexanols, axial W_h = 22–18.5 and equatorial W_h = 7.0 Hz) or from the piperidine series (*cis*- and *trans*-1-methyl-4-phenyl-3-piperidinols, axial W_h = 16 and equatorial W_h = 6 Hz),[14] the measurement of the band width at one-half band height (see Table I) clearly showed a preference for an axial-3 substituent (an equatorial proton) (**7a**).

TABLE I
CONFORMATIONAL PREFERENCES OF 3-SUBSTITUTED 1-METHYL-4-PHENYL-1,2,3,6-TETRAHYDROPYRIDINES

		3-Hydrogen		5-Hydrogen		
Compound	X	τ	W_h, Hz	τ	W_h, Hz	Conformational preference of X
1b	Br	4.81	6.4	3.92	7.4[a]	Axial
1b·HBr	Br	4.50	6.0	3.93	7.4[b]	Axial
1c	OH	5.62	6.4	3.92	7.4[a]	Axial
1c·HCl	OH	5.15	6.6	3.98	7.0[a]	Axial
1e	OAc	4.05	7.2	3.69	7.0[a]	Axial
1e·HBr	OAc	4.00	6.0	3.80	6.1[b]	Axial
1d	Cl	5.15	7.0	3.98	7.5[a]	Axial
1d·HCl	Cl	4.74	6.6	3.98	7.2[a]	Axial

[a] Separation of the terminal peaks of a quartet. [b] Separation of the terminal peaks of a multiplet.

It is noteworthy that conformation **7e** is required for nitrogen participation in the solvolytic displacement while conformation **7a** is favorable for the formation of the allylic cation. The relative stabilities of the two conformations, **7a** and **7e**, do not necessarily reflect the relative stabilities of the transition states for path A and path B,[15] but it is interesting to note that the conformation preferred in the ground-state equilibrium, conformation **7a**, is also the one which is required for path A, the reaction pathway that is observed. Thus the factors which lead to the stability of **7a** relative to **7e** are probably important in determining the relative stabilities of the transition states for path A and path B.



Experimental Section

1-Methyl-3-bromo-4-phenyl-1,2,3,6-tetrahydropyridine (1b) Hydrobromide. A.—A solution of 2.5 g (7 mmoles) of 1-methyl-3,4-dibromo-4-phenylpiperidine (**2**) hydrobromide in 20 ml of glacial acetic acid was evaporated on a steam bath under reduced pressure until the acetic acid had been removed and the molten residue had solidified. The solid was recrystallized from glacial acetic acid to give 1.2 g (60%) of **1b**, mp 186–188°, λ_{max}^{EtOH} 243 mμ (log ε 4.09).

Anal. Calcd for $C_{12}H_{15}Br_2N$: C, 43.27; H, 4.54; N, 4.21. Found: C, 43.87; H, 4.87; N, 4.11.

B.—Phosphorus tribromide (20 ml) was cooled to 5°, 1.90 g (0.01 mole) of the solid 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol (**1c**) was added, and the solid which precipitated was collected by filtration. The crude material was triturated in methanol, isolated by filtration, and recrystallized from glacial acetic acid to give 2.6 g (78%) of **1b** as a white solid, mp 185–188°. This solid was shown by infrared spectrum and mixture melting point to be identical with **1b** prepared by method A.

The reaction of 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine-d_3 hydrobromide (1a-d_3) with bromine by the method of McElvain and Safranski[7] followed by heating as in method A gave a white solid, mp 185–188°. The nmr spectrum of this solid was similar to that of undeuterated **1b** prepared by method A; however, integration of this spectrum showed approximately 0.75 proton at both the 3 and 5 position. Thus the deuterium was distributed evenly over the two positions involved.

1-Methyl-3-chloro-4-phenyl-1,2,3,6-tetrahydropyridine (1d) Hydrochloride.—A solution of 12.25 g (0.05 mole) of 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol (**1c**) hydrochloride in 100 ml of thionyl chloride was heated under reflux for 5 hr. The thionyl chloride was removed under reduced pressure and 40 ml of *n*-heptane was added and removed by distillation. Crystallization of the residue from acetone gave 11.2 g (85%) of the hydrochloride of **1d**, and recrystallization from dimethylformamide gave 10.1 g (76%) of **1d** hydrochloride as white crystals, mp 198–199°, $\lambda_{max}^{H_2O}$ 243 mμ (log ε 4.09).

Anal. Calcd for $C_{12}H_{15}Cl_2N$: C, 59.02; H, 6.19. Found: C, 59.58; H, 6.37.

1-Methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol-d_5 (1c-d_5).—The reaction of 11.3 g of 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine-d_5 hydrobromide (1a-d_5) with sodium bromide–bromine in water according to the procedure previously described[16] gave 14.1 g (89%) of **1-methyl-3-bromo-4-phenyl-4-piperidinol-d_5 hydrobromide (8-d_5)**, mp 193–196° (lit.[10] mp 195–197° for nondeuterated **8**). The reaction of **μ-d_5** with sodium hydroxide according to the procedure described previously[16] gave **1-methyl-4-phenyl-3,4-epoxypiperidine-d_5 (6-d_5)** in 91% yield, mp 44–45° (lit.[10] 45–46° for nondeuterated). The reaction of **6-d_5** with phenyllithium as described previously gave a 58% yield of **1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol-d_5 (1c-d_5)**. The signal for the vinyl proton represented only 0.1 of the area of that of the aromatic hydrogens. Thus elimination to give **1c-d_5** occurred with loss of 50% of the deuterium from the 5 position.

The reaction of 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol-d_5 (1c-d_5) hydrochloride with thionyl chloride by the method above gave 1-methyl-3-chloro-4-phenyl-1,2,3,6-tetrahydropyridine-*d* (**1d**-*d*) hydrochloride in 69% yield. Integration of the nmr spectrum of the free base indicated that the deuterium label was divided evenly between the 3 and 5 positions.

1-Methyl-3-chloro-4-phenyl-1,2,3,6-tetrahydropyridine (1d) Hydrotosylate.—A solution of 4.5 g (0.02 mole) of **1c** hydrochloride in 150 ml of dimethylformamide was heated at 50° overnight with 9.5 g of *p*-toluenesulfonyl chloride. After cooling, the mixture was poured into 500 ml of ether. The solid which formed was separated by filtration and recrystallized from isopropyl alcohol to give the hydrotosylate of **1d** as a white solid, mp 199–202°.

Anal. Calcd for $C_{19}H_{22}ClNO_3S$: C, 60.06; H, 5.83. Found: C, 60.15; H, 5.99.

Treatment of **1d** hydrotosylate with base gave a yellow oil

(13) E. Eliel and M. C. Knoeber, *J. Am. Chem. Soc.*, **88**, 5347 (1966); P. J. Brignall, A. R. Katritzky, and P. L. Russell, *Chem. Commun.*, 723 (1966), and references cited therein.

(14) R. E. Lyle, D. McMahon, C. K. Spicer, and W. E. Krueger, *J. Org. Chem.*, **31**, 4164 (1966).

(15) E. L. Eliel, "Stereochemistry of Carbon Compounds," McGraw-Hill Book Co., Inc., New York, N. Y., 1962, p 237.

(16) Methods A and B are given in ref 10 (p 395).

whose infrared spectrum was identical with that of the base obtained on treating the hydrochloride of **1d** with base.

The reaction of 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol-d_5 (1c-d_5) hydrochloride with *p*-toluenesulfonyl chloride by the method above gave 1-methyl-3-chloro-4-phenyl-1,2,3,6-tetrahydropyridine-*d* (**1d**-*d*) hydrotosylate. Recrystallization of this solid from wet isopropyl alcohol gave white plates, mp 202–203°. Integration of the nmr spectrum of the free base indicated that the deuterium label was divided evenly between the 3 and 5 positions.

1-Methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridyl Acetate (1e) Hydrobromide.—A solution of 8.5 g (0.045 mole) of 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol (**1c**) and 1.5 g of sodium acetate in 60 ml of acetic anhydride was heated under reflux for 6 hr and cooled in an ice bath. The mixture was made basic with an excess of potassium carbonate and the water layer was extracted three times with 50-ml portions of ether. The combined organic layers were dried over potassium carbonate and evaporated to give a dark oil. Dissolution of this oil in acetone followed by treatment with hydrogen bromide gave, in three crops, 11.5 g (81%) of 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridyl acetate (**1e**) hydrobromide. Recrystallization from ethanol gave an analytical sample, mp 230–232°, $\lambda_{max}^{H_2O}$ 240 mμ (log ε 4.07).

Anal. Calcd for $C_{14}H_{18}BrNO_2$: C, 53.86; H, 5.81; N, 4.49. Found: C, 53.88; H, 5.87; N, 4.74.

The Solvolysis of 1-Methyl-3-chloro-4-phenyl-1,2,3,6-tetrahydropyridine (1d) Hydrobromide.—A solution of 0.8 g (0.02 mole) of sodium hydroxide in 10 ml of water was added to 1.0 g (4 moles) of **1d** hydrochloride in 10 ml of water. The mixture was heated at 80° for 1 hr, cooled, and extracted four times with 50-ml portions of ether. The combined organic layers were dried over potassium carbonate and evaporated to give 0.75 g (100%) of a yellow solid. Gas chromatographic analysis of this solid on a 1-m Carbowax 20M column indicated that it contained only one volatile component. Recrystallization of this solid from *n*-heptane gave 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol (**1c**), mp 101–103°.

The Solvolysis of 1-Methyl-3-bromo-4-phenyl-1,2,3,6-tetrahydropyridine (1b) Hydrobromide. A.—A solution of 0.5 g (0.5 mmole) of **1b** in 15 ml of water was heated on a steam bath for 0.5 hr. Isolation as above gave 0.23 g (83%) of **1c**, mp 101–103°, as shown by infrared spectrum and vpc retention time.

B.—A solution of 0.3 g (8 mmoles) of sodium hydroxide in 5 ml of water was added to a solution of 1.0 g (3 mmoles) of **1b** in 50 ml of water and stirring was maintained at room temperature for 2 hr. Isolation as above gave 0.40 g (70%) of a pale yellow solid. Recrystallization of the solid from *n*-heptane gave 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol (**1c**), mp 99–102°, as shown by vpc retention time and infrared spectrum.

The Reaction of 1-Methyl-3-bromo-4-phenyl-1,2,3,6-tetrahydropyridine (1b) Hydrobromide with Weak Aqueous Base.—To a mixture of an aqueous solution of potassium carbonate and ether was added 1.0 g (3 mmoles) of 1-methyl-3-bromo-4-phenyl-1,2,3,6-tetrahydropyridine (**1b**) hydrobromide. The mixture was shaken until, on standing, both layers were homogeneous. The water layer was drawn off and the ether layer was dried over potassium carbonate. The organic layer was evaporated and the solid residue was triturated with acetone. Recrystallization from water gave 0.2 g (18%) of a white solid, mp 238–241°. The infrared spectrum of the solid had a broad band at 3400 cm^{-1}; the elemental analyses were correct for a dimer plus a molecule of water, and the ultraviolet spectrum indicated the presence of two isolated styryl groups. A likely structure for this compound is 1-methyl-1-[3-(1-methyl-4-phenyl-1,2,3,6-tetrahydropyridyl)]-3-bromo-4-phenyl-1,2,3,6-tetrahydropyridinium bromide monohydrate; $\lambda_{max}^{H_2O}$ 245 mμ (log ε 4.34).

Anal. Calcd for $C_{24}H_{30}Br_2N_2O$: C, 55.19; H, 5.79; N, 5.36; Br, 30,60. Found: C, 54.92; H, 5.96; N, 4.73. Found (Mohr method): Br, 30.85.

The Attempted Thermal Rearrangement of 1-Methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridyl Acetate (1e).—A sample of the acetate **1e**, mp 78–80°, was distilled under aspirator pressure. The distillate was collected as a single fraction with the largest amount boiling from 177–179°. The product was identified by its vpc retention time and infrared spectrum as unrearranged **1e**. The analysis by gas chromatography showed that within the limits of detection no rearrangement had occurred.

The Hydrolysis of 1-Methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridyl Acetate (1e).—A mixture of 1.1 g (5 mmoles) of **1e** and water was heated above the melting point of the organic material, and a solution of 0.8 g of sodium hydroxide in 5 ml of water was added. The mixture was heated under reflux for 24 hr and cooled to 10° in an ice bath. The solid which separated was collected by filtration, dissolved in ether, and dried over potassium carbonate. The vapor phase chromatographic analysis of this solution indicated the presence of only one volatile component which was identified by its retention time as 1-methyl-4-phenyl-1,2,3,6-tetrahydro-3-pyridinol (**1c**). Evaporation of the ether gave a white solid, mp 101–104°, after recrystallization from *n*-heptane. This solid was shown by infrared spectrum to be **1c**.

Registry No.—**1b**, 14164-47-7; **1b**-HBr, 14164-48-8; **1b**-*d*, 14164-49-9; **1c**, 1891-24-3; **1c**-HCl, 13427-23-1; **1c**-d_5, 14271-26-2; **1d**, 14164-52-4; **1d**-HCl, 14271-27-3; **1d**-hydrotosylate, 14164-53-5; (**1d**-*d*)-HCl, 14164-54-6; **1d**-*d*-hydrotosylate, 14164-55-7; **1e**, 14164-56-8; **1e**-HBr, 14164-57-9; **3**, 14164-58-0.

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The Reduction of Some Flavylium Salts With Sodium Borohydride

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Reduction of flavylium perchlorate with sodium borohydride in several primary alcohols gave dimers which were assigned structures **3a**, **3b**, and **3c**. A mechanism for this reaction is postulated. The reduction was carried out in acetonitrile and *t*-butyl alcohol and the product was found to be 4H-flavene (**2**). Several substituted flavylium salts were reduced by means of sodium borohydride in ethanol and structures were assigned to the products.

Only few examples of the reduction of pyrylium or flavylium salts by means of metal hydride reducing agents have appeared in the literature. Recently, it was shown[1] that the reduction of 2,4,6-trimethylpyrylium perchlorate by means of sodium borohydride in ether gives two dienones which no longer possess a cyclic structure.

Since flavylium salts are more resistant to ring cleavage than are pyrylium salts, we thought that it would be of interest to investigate the reduction of flavylium

(1) A. T. Balaban, G. Mihai, and C. D. Nenitzescu, *Tetrahedron*, **18**, 257 (1962).